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Short Communication: Biological aspects of *Charybdis anisodon* (De Haan, 1850) in Lasongko Bay, Central Buton, Southeast Sulawesi, Indonesia

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Abstract. *Hamid A, Wardiatno Y. 2018. Short Communication*: *Biological aspects of* Charybdis anisodon (*De Haan, 1850) in Lasongko Bay, Central Buton, Southeast Sulawesi, Indonesia. Biodiversitas 19*: *1755-1762.* Data on the biological aspects of *Charybdis anisodon* (De Haan, 1850) were still very limited. This study was aimed to determine the distribution of size, growth type, sex ratio and spawning season of *C. anisodon* in Lasongko Bay, Central Buton, Southeast Sulawesi. Crab collection was conducted from May 2013 to March 2014 using a crab gillnet. The carapace width of males and females *C. anisodon* ranged between 3.05-7.61 cm and 3.45-7.98 cm, respectively. Mann-Whitney test showed that width and length of carapace of males and females were significantly different ($p<0.05$). Type of growth of carapace width-body weight male and female were both allometric negative. Carapace length-body weight relationships of the males was isometric, but it was allometric negative for females. Spatially and temporally, the sex ratio of *C. anisodon* showed a variation, and the total sex ratio was 1: 0.38. The spawning season of *C. anisodon* tend to occur throughout the year.

Keywords: Allometric relationship, crustacea, growth type, sex ratio, spawning season, two-spined arm swimming crab

INTRODUCTION

Charybdis anisodon (De Haan, 1850) spreads across the Indo-West Pacific to Africa including Hawaii, Australia, New Zealand, Papua New Guinea, Indonesia, Philippines, Malaysia, Singapore, Thailand, Vietnam, Japan, India, China, Red Sea, Madagascar, Mayotte and Tanzania (Ng 1998; Chung 2002; Chande and Mgaya 2003; Kunsook and Dumrongrojwatthana 2017; GBIF 2018). The crab prefers waters with muddy substrate and can still be found to a depth of 25 m (Ng 1998, Chung 2002). This crab is edible and has economic value (Ng 1998, Santhanam 2018), but the value is lower than *Portunus pelagicus*.

From biological point of view, information on the size distribution, the relationships between carapace sizes and body weight, sex ratio, first-sex maturity and spawning season are needed in sustainable crab fisheries management (Kamrani et al. 2010; Ikhwanuddin et al. 2012, Hamid et al 2016b, 2017). Researches on biological aspect of the genus *Charybdis* have been carried out on *C. natator* (Sumpton 1990; Sallam and Gab-Alla 2010; Kannathasan and Rajendran 2011; Vidhya 2016), *C. affinis* (Chu 1999), *C. hellerii* (Mantelatto and Garcia 2001, Sant'Anna et al., 2012, Ferry et al., 2017), *C. bimaculata* (Doi et al. 2010), *C. feriatus* (Dineshbabu 2011; Nieves et al., 2015) and *C. japonica* (Fowler 2011; Wong. 2013), but it is lacking in *C. anisodon*.

The research on crustacea in Lasongko Bay regarding to the stock of shrimp and crab in general has been conducted by Supardan (2006). More researches in the bay were focused on the blue swimming crab (*P. pelagicus*) biology, i.e. reproductive biology (Hamid et al. 2015, 2016a, b, c), population dynamics, stock and management of the blue swimming crab (Hamid and Wardiatno 2015; Hamid et al. 2016d, 2017). The two-spined arm swimming crab, *C. anisodon* in Lasongko Bay is one of the bycatch species of blue swimming crab fishery with local economic value. This study was aimed to determine some biological aspects of *C. anisodon* including size distribution, growth type, sex ratio, and spawning season.

MATERIALS AND METHODS

Location and study period

The study was conducted from May 2013 to March 2014 at Lasongko Bay of Central Buton District, Indonesia with position 05°15'-05°27' S and 122°27'-122° 33'E. The sampling location of *C. anisodon* covered the head of the bay to the center of the bay and consisted of six stations (Figure 1).

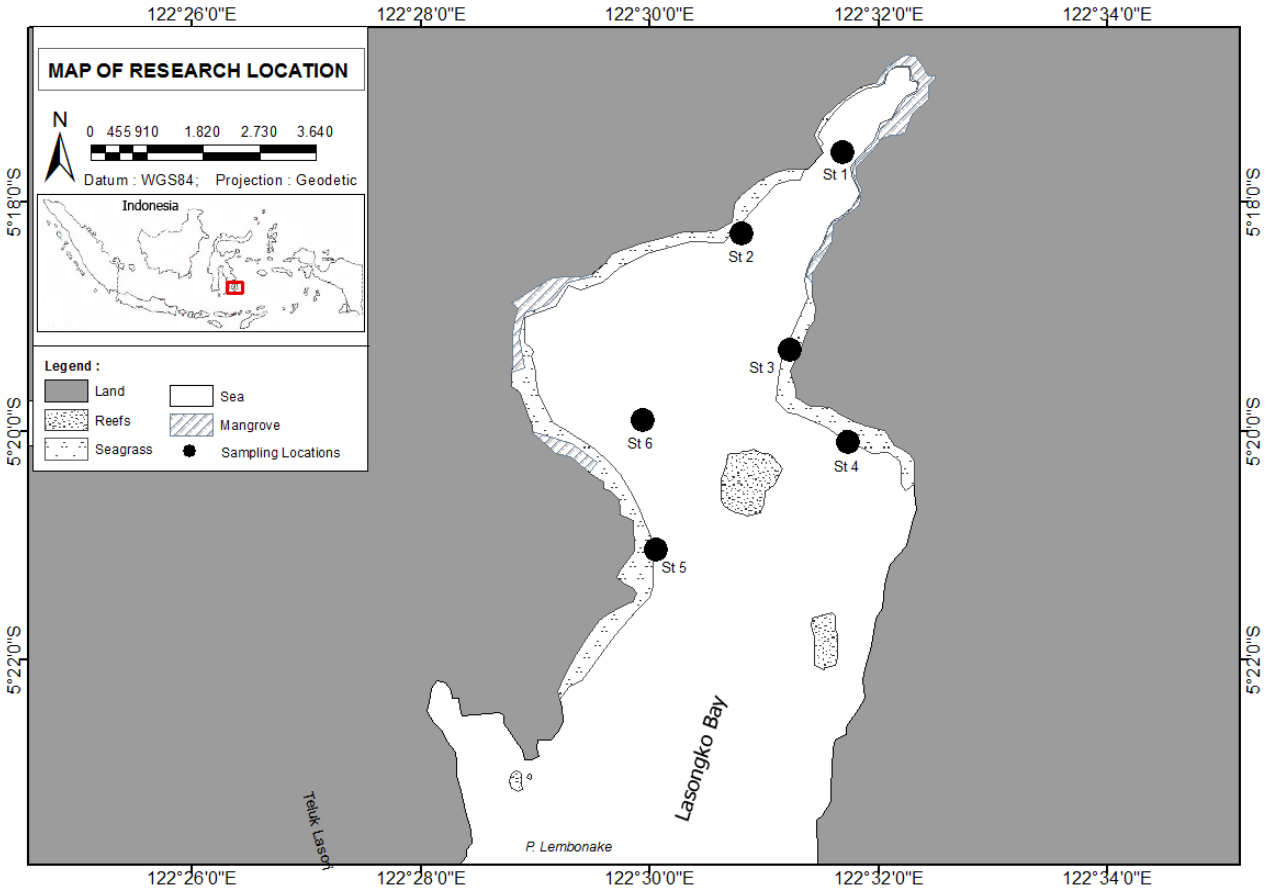


Figure 1. Location map and research station in Lasongko Bay (adapted from Hamid and Wardiatno 2015)

Sampling

Sampling of *C. anisodon* was conducted once a month on each station using gillnet. Gillnets were set at each station in the afternoon and hauled in the morning of the next day. The collected crabs were separated according to station, sex and counted. The carapace width and length were measured with calipers (Vernier Caliper with precision 0.05 mm), and the weight was weighed with a digital scale (Xon Med Digital Scale) with a precision of 0.01 g.

Determination of Size Class Distribution

The data of carapace width of male and female *C. anisodon* were tabulated and presented with the size class distribution with the width of the class of 0.5 cm. The carapace width and length between males and females totally were tested with Mann-Whitney-test at p = 0.05 (Steel and Torrie 1992) to determine the size difference between sexes.

Determination of Carapace Width-Body Weight and Carapace Length-Body Weight Relationships

The carapace width or carapace length with body weight relationship of *C. anisodon* were determined by the power and linear equations (Hartnoll 1978; Josileen 2011; Hamid 2015), i.e. by the equation as follows:

$$Bw = aCW^b \quad \text{..... (1)}$$

Bw = body weight (g), CW = carapace width (cm) or carapace length (cm), a = intercept and b = growth coefficient. To simplify calculation, the equation (1) was transformed to $\log_{10}$ to obtain linear equations as follows:

$$\text{Log } Bw = \log a + b \log CW \quad \text{..... (2)}$$

To determine the growth type of allometric relationships between carapace width/length and body weight of *C. anisodon*, the test of b value equal to 3 was performed with t-test at p = 0.05 (Steel and Torrie 1992). If the b = 3 it is isometric, if the value of b <3 it is negative allometric, and if the b> 3 is positive allometric (Hartnoll 1978; Josileen 2011).

Determination of sex ratio and spawning season

The sex ratio of *C. anisodon* is the ratio of the number of females to the number of males caught on each station and sampling period. Sex ratio of *C. anisodon* was calculated by the following equation:

$$\text{Sex ratio} = \frac{\sum \text{Female}}{\sum \text{Male}} \quad \text{..... (3)}$$

The total sex ratios of *C. anisodon* was tested by chi-square test ($\chi 2$) at p = 0.05 (Steel and Torrie 1992) to determine of sex ratio 1: 1. The spawning season of *C. anisodon* was determined based on the presence of ovigerous female (Sukumaran 1995; Karmani et al. 2010; Hamid et al. 2015; Ernawati et al. 2017).

RESULTS AND DISCUSSION

The number and carapace size

The number of male *C. anisodon* ranged between 6 and 35 individual while the female ranged from 1 to 16 individuals per sampling period. The total number of male caught at each station ranged between 3 and 120 individuals and the female ranged between 1 and 51 individuals. The samples were mostly caught in stations 1 and 2, but it was rarely found in stations 3, 4, 5 and 6. In terms of sampling period, the crabs were mostly caught in January 2014, but was hardly found in September and June 2013 (Table 1).

The carapace width and length of the male ranged between 3.05 and 7.61 cm and between 2.81 and 4.61 cm, respectively. While the carapace width and length of the female ranged between 3.45 and 7.98 cm and between 1.96 and 3.93, respectively. The average of carapace width and length of both sexes of *C. anisodan* was listed in Table 2. Mann-Whitney test of carapace width and length of *C. anisodon* showed a significantly different ($p<0.05$) between males and females (Table 2). Body size (carapace width and length) of male was larger than females, and this is identical to those found in some other species of *Charybdaris*, such as *C. feriatus* (Dineshbabu 2011; Dash et al. 2014), *C. natator* (Sumpton 1998; Sallam and Gab-Alla 2010; Vidhya 2016), *C. bimaculata* (Doi et al. 2008), *C. hellerii* (Ozcan et al. 2010; Sant'Anna et al. 2012; Ferry et al. 2017) and *C. japonica* (Fowler 2011; Wong 2013).

Among the species of the genus *Charybdis*, *C. anisodon, C. hellerii* and *C. japonica* are categorized as small-sized species while *C. natator, C. bimaculta* and *C. feriatus* are the large-sized ones. The carapace width of male *C. hellerii* ranged between 2.5 and 7.8 cm and female ranged between 1.73 and 6.50 cm (Ozcan et al. 2010; Bolanos et al. 2012; Sant'Anna et al. 2012; Ferry et al. 2017), carapace width of male *C. japonica* ranged between 2.8 and 10.37cm and female ranged between 2.8 and 9.9 cm (Fowler 2011; Wong 2013). The maximum carapace width of *C. feriatus* and *C. natator* reached 20 cm and 17 cm, respectively (Ng 1998), and carapace width of the male *C. bimaculata* ranged between 5.35 and 24.14 cm and the female ranged between 4.94 and 20.75 cm (Doi et al. 2008).

In Lasongko Bay, the male *C. anisodon* was dominated by the 5.09-5.59 cm carapace width class size, while the female was dominated by the 4.07-4.57 cm carapace width class size (Figure 2). The carapace width class size distribution of male and female *C. hellerii* in Martinique, French was dominated by the 3.70-3.95 cm class size (Ferry et al. 2017), while Ozcan et al. (2010) found the dominant class size was 6.1-7.0 cm in males and 5.1-6.0 cm in female for the same species in Iskenderun Bay, Turkish.

Table 1. The number of *C. anisodon* caught on each station during the study in Lasongko Bay, Central Buton, Southeast Sulawesi

Collection date	Number of crab on each station and sex (individual)											
	1		2		3		4		5		6	
	M	F	M	F	M	F	M	F	M	F	M	F
May 2013	3		7	2			2					1
June 2013	4	4					1		1			
July 2013	16	2	2									
Augusts 2013	13	3							1			
September 2013			6	1								
October 2013	15	1	1		2	1		3				
November 2013	13	15	1	1								
December 2013	16	3										
January 2014	18	9	11		2		1		2		1	
February 2014	13	10	1		1		1			6	3	
March 2014	9	4	6				2				2	

Note: M = Male F = Female

Table 2. The Carapace size of male and female *C. anisodon* in Lasongko Bay, Central Buton, Southeast Sulawesi

Station	Carapace width (cm)		Carapace length (cm)	
	Male	Female	Male	Female
1	5.18±0.56	4.53±0.66	2.97±0.30	3.49±0.32
2	5.57±0.78	4.57±0.45	3.17±0.49	2.52±0.23
3	5.63±1.02	4.66	3.18±0.56	2.52
4	5.65±1.01	4.61±0.18	3.39±0.41	2.55±0.14
5	6.10±0.69	4.91±0.32	3.50±0.50	2.71±0.15
6	6.24±1.19	3.45	3.62±0.70	1.97
Average	5.34±0.71a	4.56±0.62b	3.06±0.40a	2.51±0.30b

Note: a and b are significantly different at $p<0.05$.

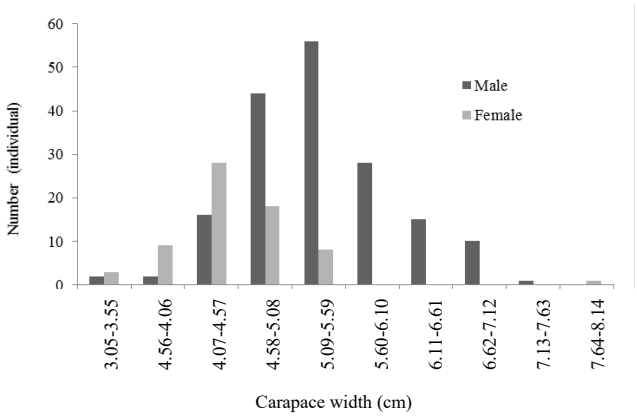


Figure 2. The carapace width class size distribution of *C. anisodon* in Lasongko Bay, Central Buton, Southeast Sulawesi

Carapace width/length-body weight relationships

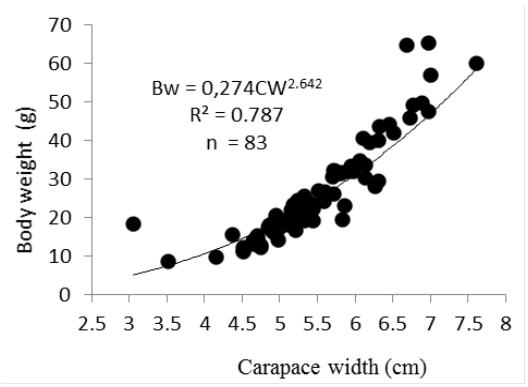
The analysis results of the relationships of carapace width and carapace length with the body weight of male and female *C. anisodies* can be seen in Table 3 and Figure 3. The r-values of the relationships between the carapace width and the carapace length with body weight the male were 0.887 and 0.949, respectively; while in the female they were of 0.835 and 0.858, respectively. All relationships were very strong and positive. The carapace width-body weight relationship of male and female *C.*

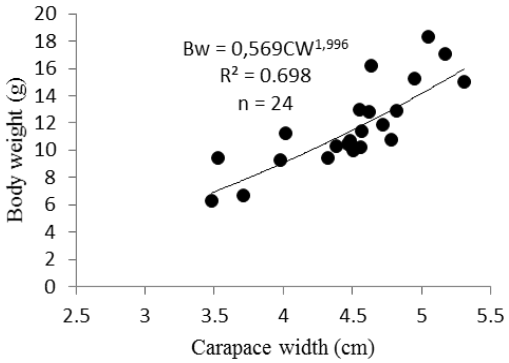
anisodies showed allometric negative (t-test, p<0.05) with b-value of 2.642 and 1.996, respectively. The carapace length-body weight of male *C. anisodon* relationships showed b value of 3.021, and the result of t-test of the value was not significantly different (p> 0.05) indicating isometric growth. Meanwhile, in the female *C. anisodon* the b value was 2.244 and t-test result of the value was significantly different (p <0.05) indicating negative allometric growth (Table 3).

Table 3. Carapare width/length-body weight relationship, correlation coefficient (r), t-test of b value and growth type of *C. anisodon* with linear equations in Lasongko Bay, Central Buton, Southeast Sulawesi

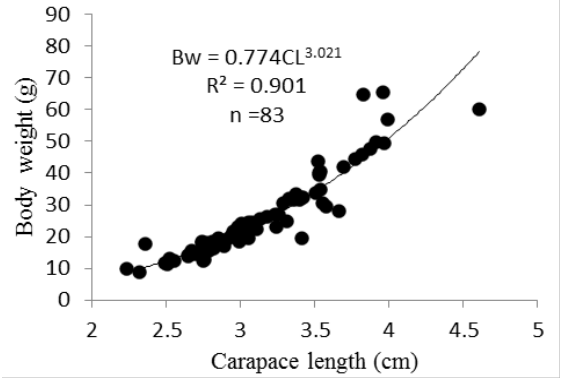
Relationship	Linear equations	r	t-test for b=3	Growth type
Carapace width- Body weight				
Male	LogBw = - 0.561 + 2.642logCW	0.887	9.396*	Negative Allometric
Female	LogBw = -0.244 + 1.996 logCW	0.835	5.522*	Negative Allometric
Carapace length- Body weight				
Male	LogBw = -0,111 + 3,021logCL	0.949	0.905^{ns}	Isometric
Female	LogBw = 0,162 + 2,244logCL	0.858	62.858*	Negative Allometric

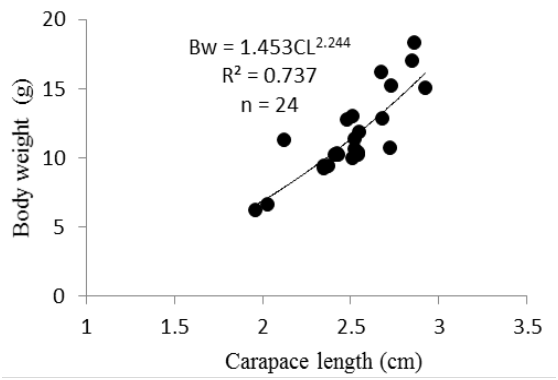
Note: *significantly different (p<0.05) ns = not significantly different (p>0.05)





Male **Female**





Male **Female**

Figure 3. Carapace width/length-body weight relationship of male and female *C. anisodon* in Lasongko Bay, Central Buton, Southeast Sulawesi

Table 4. The b value and the growth type of some *Charybdis* species in different locations

Location	Spesies (Sex)	Relation	b value	Growth type	Source
Tokyo Bay, Japan	*C. bimaculata* (M)	CL-Bw	3.312	Positive Allometric	Doi et al. 2008
	C. bimaculata (M)	CL-Bw	3.038	Positive Allometric	
Suez Bay, Egypt	*C. natator* (M)	CW-Bw	2.9771	Negative Allometric	Sallam and Gab-Alla
	C. natator (F)	CW- Bw	3.064	Positive Allometric	2010
Mannar Bay, India	*C. natator* (M)	CW- Bw	3.387	Positive Allometric	Vidhya 2016
	C. natator (F)	CW- Bw	2.958	Isometric	
	C. natator (M)	CL- Bw	3.428	Positive Allometric	
	C. natator (F)	CL- Bw	2.939	Isometric	
Northeastern New Zealand	*C. japonica* (M	CW- Bw	3.1413	Positive Allometric	Fowler 2011
	C. japonica (F)	CW- Bw	3.2015	Isometric	
San Miguel Bay, Philippines	C. *feriatus* (M)	CW- Bw	2.83	Negative Allometric	Nieves et al. 2015a
	C. *feriatus* (F)	CW- Bw	2.73	Negative Allometric	
Karnataka, India	*C. feriatus* (M)	CW- Bw	3.078	Positive Allometric	Dineshbabu 2011
	C. feriatus (F)	CW- Bw	3.005	Positive Allometric	
Veraval, India	*C. feriatus* (M)	CW- Bw	2.94	Isometric	Dash et al. 2014
	C. feriatus (F)	CW- Bw	2.97	Isometric	
Lasongko Bay, Central Buton,	*C. anisodon* (M)	CW- Bw	2.642	Negative Allometric	This study
Southest Sulawesi,	*C. anisodon* (F)	CW- Bw	1.996	Negative Allometric	
Indonesia	*C. anisodon* (M)	CL- Bw	3.021	Isometric	
	C. anisodon (F)	CL- Bw	2.244	Negative Allometric	

Note: M = Male F = Female CW = Carapace width CL = Carapace length Bw = Weigth body

The value of b relationship of carapace width/length-body weight of male *C. anisodon* in this study was larger than that of females. This is identical to those of *C. natator* in Manar Bay, India (Vidhya 2016), and carapace width-body weigth relationships of *C. feriatus* in San Miguel Bay, Philippines (Nieves et al. 2015a) and in the coast of Karnataka, India (Dineshbabu et al. 2011), as well as the carapace length-body weight relationship of *C. bimaculata* in Tokyo Bay, Japan (Doi et al. 2008). The b-values the carapace width-body weight relationship in male and female *C. anisodon* were smaller than those in *C. natator, C. feriatus, C. hellerii* and *C. japonica* (see Table 4). The b-values of carapace length-body weight of male and female *C. anisodon* were also smaller than the b values of carapace length-weight *C. bimaculata* in Tokyo Bay, Japan (Doi et al. 2008) and *C. natator* in Manar Bay, India (Vidhya 2016). The growth type of carapace width-body weight relationship of male and female *C. anisodon* in this study was identical to that found at *C. feriatus* in San Miguel Bay, Philippines (Nieves et al. 2015a). The growth type of the carapace length-body weigth relationship of male and female in *C. bimaculata* of Tokyo Bay, Japan are both positive allometrics (Doi et al. 2008), and male *C. natator* in Manar Bay, India is positive allometric whereas in females is isometric (Vidhya 2016).

Sex ratio

The number of *C. anisodon* caught during the study was 243 individuals consisting of 176 males and 67 females. The sex ratio of *C. anisodon* at each station was varied, with the highest value was found at station 5 and lowest at station 2 (Table 5). The total sex ratio of *C. anisodon* was 1: 0.38, and the results of $\chi 2$-test was significantly different ($p<0.05$) with a ratio of 1: 1 or unbalanced between males and females.

Based on the sampling period, the number of male and female of *C. anisodon* was also varied (Table 6). The sex ratio of *C. anisodon* based on the sampling period ranged 1: 0.11 - 1: 1.14 with the highest was found in November 2013, and the lowest was in May 2013 (Table 6). Generally, the number of male *C. anisodon* was higher than the female, except for November 2013. Based on the total sex ratios, it seems that one male *C. anisodon* can fertilize as much as two to three females.

The total sex ratio of *C. anisodon* was generally smaller than those of some other species of *Charybdis* found in some waters in the world (Table 7), except for the sex ratio of *C. hellerii* found in Iskenderun Bay, Turkey (Ozcan et al. 2010) and in São Vicente, Brazil (Sant'Anna et al. 2015) were larger. Variation in sex ratio occurred also spatially and temporally in this study. Similar patterns were found in population of *P. pelagicus* in the Lasongko Bay (Hamid et al. 2016a) and in *C. natator* in Bengal Bay, India (Kannathasan and Rajendran 2011). The variation in sex ratio is probably due to spawning and feeding migration in the portunid groups, the different type of fishing gear used as well as the season (Kannathasan and Rajendran 2011; Hamid et al. 2016b), or due to the differences in age and growth rate (Doi et al. 2008).

Ovigerous females and spawning season

The number of ovigerous female of *C. anisodon* was 43 individuals or 64.18% of the total females found during the study. Ovigerous females *C. anisodon* were collected from stations 1, 2, 4 and 5 (Table 8), but majority were found at station 1 (32 individuals) in February 2014 (Figure 4). Ovigerous females *C. anisodon* generally could be found every month during the study, except for July. Carapace width of ovigerous females *C. anisodon* in Lasongko Bay ranged from 3.48 to 7.98 cm; whilst carapace lengths

ranged from 1.96 to 3.06 cm. The presence of ovigerous females indicates that the spawning season of *C. anisodon* in Lasongko Bay tend to to occur all year-round with three peaks, i.e. in February (highest), November and June (Figure 4).

The carapace width of ovigerous female *C. anisodon* found in this study was larger than that of ovigerous female *C. hellerii*, i.e. 3.82 cm (Ferry et al. 2017), but smaller than that of *C. japonica*, i.e. 6.25±0.24 cm (Wong 2013) and *C. natator,* i.e. 9.4 cm (Sumpton 1998).

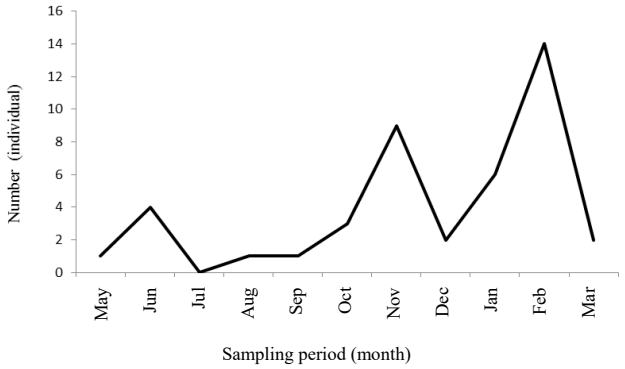


Figure 4. The presence of ovigerous females *C. anisodon* at each month in Lasongko Bay, Central Buton, Southeast Sulawesi

Table 5. Number and sex ratio of *C. anisodon* at each of station in Lasongko Bay, Central Buton, Southeast Sulawesi

Station	Number (individual)		Proportion (%)		Sex ratio Male: Female
	Male	Female	Male	Female	
1	120	51	70.2	29.8	1: 0.43
2	35	4	89.7	10.3	1: 0.11
3	5	1	83.3	16.7	1: 0.20
4	7	3	70.0	30.0	1: 0.43
5	3	7	30.0	70.0	1: 2.33
6	6	1	85.7	14.3	1: 0.17
Total	176	67	72.4	27.6	1: 0.38*

Note: * significantly different (p<0.05)

Table 6. Number and sex ratio of *C. anisodon* on every month in Lasongko Bay, Central Buton, Southeast Sulawesi

Month	Number of sample (individual)		Proportion (%)		Sex Ratio
	Male	Female	Male	Female	Male: Female
May 2013	12	3	80.0	20.0	1: 0.25
June 2013	6	4	60.0	40.0	1: 0.67
July 2013	18	2	90.0	10.0	1: 0.11
August 2013	13	4	76.5	23.5	1: 0.31
September 2013	6	1	85.7	14.3	1: 0.17
October 2013	18	5	78.3	21.7	1: 0.28
November 2013	14	16	46.7	53.3	1: 1.14
December 2013	16	3	84.2	15.8	1: 0.19
January 2014	35	9	79.5	20.5	1: 0.26
February 2014	19	16	54.3	45.7	1: 0.84
March 2014	19	4	82.6	17.4	1: 0.21
Total	176	67	72.4	27.6	1: 0.38*

Note: * significantly different (p<0.05)

Table 8. Time, caught location and carapace width of ovigerous female *C. anisodon* in Lasongko Bay, Central Buton, Southeast Sulawesi

Month	Caught location (station)	Carapace width (cm)
May 2013	2	4.25
June 2013	1	3.93-5.41
July 2013	-	-
August 2013	5	5.24
September 2013	1	4.32
October 2013	4	4.51-4.82
November 2013	1 dan 2	3.80-4.82
December 2013	1	4.62-4.88
January 2014	1	3.71-7.98
February 2014	1 dan 5	3.48-5.31
March 2014	1	3.96-4.02
Mean carapace width (cm)		4.62±0.70

Note: - = not found

Table 7. Sex ratio and spawning season of several species of *Charybdis* at different locations

Location	Species	Sex Ratio	Spawning Season	Source
Tokyo Bay, Jepang	*C. bimaculata*	1: 2.07	Not year-round	Doi et al. 2008
Mangalore, India	C. *feriatus*	1: 1	-	Babu et al. 2006
Karnataka, India	C. *feriatus*	1: 1	Year-round	Dineshbabu 2011
San Miguel Bay, Philippines	C. *feriatus*	1: 0.50	Year-round	Nieves et al. 2015b
Iskenderun Bay, Turkey	*C. hellerii*	1: 0.24	-	Ozcan et al. 2010
São Vicente, Brazil	*C. hellerii*	1: 0.32	Year-round	Sant'Anna et al. 2012
Caribia Sea, Venezuela	*C. hellerii*	1: 0.46	Year-round	Bolanos et al 2012
Martinique, French	*C. hellerii*	1: 0.42	-	Ferry et al. 2017
Northeastern New Zealand	*C. japonica*	1: 0.56	Not year-round	Fowler 2011
Northeastern New Zealand	*C. japonica*	1: 0.65	Not year-round	Wong 2013
Moreton Bay, Queensland	*C. natator*	1: 0.55	Year-round	Sumpton 1998
Suez Bay, Egypt	*C. natator*	1: 1.10	Year-round	Sallam & Gab-Alla 2010
Nagapattinam, India	*C. natator*	1: 1.01	-	Kannathasan & Rajendran 2011
Mannar Bay, India	*C. natator*	1: 0.62	Year-round	Vidhya 2016
Lasongko Bay, Indonesia	*C. anisodon*	1: 0.38	Year-round	This study

Note: - = no data

The peak spawning season of *C. natator* in Manar Bay, India takes place from December to February (Vidhya 2016), whereas the low spawning season occur in winter in Moreton Bay, Australia (Sumpton 1998). Spawning season of other *Charybdis* species occur throughout the year and some was only in certain months (Table 8). The *Charybdis* that spawn throughout the year are *C. natator* (Sumpton 1998, Sallam and Gab-Alla 2010; Vidhya 2016), *C. feriatus* (Dineshbabu 2011; Nieves et al. 2015b) and *C. hellerii* (Bolanos et al. 2012; Sant'Anna et al. 2012). While those which did not spawn throughout the year are *C. japonica* (Fowler 2011; Wong 2013) and *C. bimaculata* (Doi et al. 2008). The spawning season of *C. bimaculata* in Tokyo Bay, Japan is only occurred from March to October (Doi et al. 2008).

In conclusion, the carapace width distribution of male and female *C. anisodon* in Lasongko Bay ranged from 3.05 to 7.61 cm and 3.45 to 7.98 cm, respectively, with an unbalanced sex ratio and the spawning season is likely occur the whole year-round. The growth type of carapace width-body weight of male and female *C. anisodon* are negative allometric, whereas the growth type of carapace length-body weight of male is isometric and females is negative allometric. Negative allomertic growth is carapace width or carapace length growth more than body weight growth, whereas isometric growth is carapace length growth balanced with body weight growth of *C. anisodan*. Growth of *C. anisodan* of males is faster than females. This research is the first report to inform the biological aspects of *C. anisodon* in Indonesia.

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